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Analysis of Student Mastery of Concept on Static Fluid Through the Guided Inquiry Flipped Classroom Model

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Abstract

This study aimed to analyze students' concept acquisition of static fluid material in the pressure sub-chapter through the Guided Inquiry Flipped Classroom (GIFC) model. This type of research is quantitative, using a one-group pretest-posttest research design. The research subjects consisted of 31 students of XI MIPA 4. The measurement instrument in this study was a concept acquisition test, which consisted of 3 essay questions. Two supervisors have guided the instruments used, and they are valid. The data analysis technique uses paired t-test analysis and effect size analysis. The results of this study indicate significant differences between the pretest and posttest by the results of the paired t-test analysis and that guided inquiry affects concept acquisition. This study implies that this guided inquiry flipped classroom effectively improves students' concept acquisition. The results of this study can be used as input for educators to use the GIFC model to improve students' concept acquisition.

Keywords: Concept acquisition; Guided inquiry; Flipped classroom

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INTRODUCTION

Static fluid is an important physics subject for every student, especially high school students. However, many studies reveal that most students do not acquire static fluid materials well. This is evidenced by research from (Besson, 2004; Yadaeni et al., 2016) that many students have difficulty with hydrostatic pressure, which is the case of related vessels; according to students, the vessel that has the greatest hydrostatic pressure is the vessel that has the narrowest space. Most students also have difficulty with Pascal's Law; students assume that the earth's gravity influences the pressure on the piston pipe (Wicaksono et al., 2019). In addition, research from (Doris et al., 2014; Wong et al., 2016) also revealed students' difficulties in Archimedes' Law, such as students had misconceptions of objects dipped in containers filled with water students think that the magnitude of the direction and buoyancy force is influenced by the mass of the object not the volume of the object. In addition, research from (Loverude et al., 2003; Minogue & Borland, 2016) found that students' acquisition of concepts is low. They cannot determine the value of the volume of the object being immersed because they cannot distinguish between mass and mass and volume. Based on this research, it can be concluded that the concept understanding possessed by students is still lacking.

Researchers made various efforts to improve students' understanding of concepts. One of them is using *the student facilitator* learning model, which is carried out to overcome student difficulties in static fluids (Pamungkas et al., 2017). In addition, problem-based learning can also be used to improve students' concept acquisition (Hamzah et al., 2022). The Project-based learning model can be implemented for students in physics learning to improve students' concept acquisition (Baran et al., 2018).

However, weaknesses were encountered in the efforts made. One is the weakness of learning with student facilitators, which is more effectively applied in classes where students are active and accustomed to making concept maps. Given that in each school, students in one class do not all consist of active students and are accustomed to making concept maps; this model will make it difficult for less active students (Pamungkas et al., 2017). In addition, the Problem Based Learning (PBL) model has weaknesses: its implementation does not involve interaction between teachers and students (Hamzah et al., 2022). The Project Based Learning (PjBL) model also has weaknesses, namely that not all materials can be applied to the PjBL model (Dwi et al., 2018).

Based on the weaknesses encountered in improving concept acquisition, it can be concluded that these efforts have not been optimally carried out. Other factors cause low concept acquisition. One of them is the lack of practice on the material in physics lessons (Zacharia & de Jong, 2014). In addition, it is also caused by the use of monotonous learning models, and the way teachers teach is still based on the old paradigm (Tompo et al., 2016). Therefore, the learning model that is suitable to use is guided inquiry because, in the learning process, the inquiry model involves the maximum ability of students to search and investigate (Maknun, 2020; Şenyiğit et al., 2019).

Guided inquiry is known to improve students' physics acquisition. This is evidenced by research conducted by (Naf'atuzzahrah et al., 2022) that using guided inquiry models is valid and feasible to improve students' physics acquisition. In addition, students' concept acquisition also increased after being given guided inquiry learning (Fry & Hillman, 2018). The guided inquiry affects students' physics learning, thus impacting students' physics (Ogegbo & Ramnarain, 2022).

However, the application of the guided inquiry model has its drawbacks. The weakness of guided inquiry is that its implementation takes a long time (Lestari & Setyarsih, 2020), and the learning steps are too long (Effendi-Hasibuan et al., 2019). This weakness can be overcome with the help of online learning, namely with a flipped classroom approach (Lestari & Setyarsih, 2020). The use of this flipped classroom approach itself is known to help improve students' physics concept acquisition. Students' physics acquisition changed after being given learning in a flipped classroom; namely, scores in the experimental group increased by 48% after being treated with a flipped classroom approach (Limueco & Prudente, 2018).

Based on the explanation above, it can be concluded that the guided inquiry model can be combined with a flipped classroom. Studies by other researchers found that previously only used guided inquiry to improve concept acquisition, misconceptions, and learning outcomes (Margunayasa et al., 2019; Orosz et al., 2022; Siantuba et al., 2023). In addition, previous research only focused on using flipped classrooms to improve student achievement, learning skills, critical thinking, and psychological stress (Atwa et al., 2022; Ramadhani et al., 2022; Wright & Park, 2022). The flipped classroom approach can be combined with guided inquiry to overcome weaknesses in the guided inquiry model (Zheng et al., 2020). Therefore, this study aims to analyze students' concept acquisition with a flipped classroom-guided inquiry model.

METHOD

This research is a type of quantitative research (Cresswell, 2009). The research design used was one group pretest and posttest. Sampling in this study was by cluster sampling technique. This study aims to analyze students' concept acquisition of static fluid material through a guided inquiry flipped classroom model. The subjects in this study were 31 students of class XI MIPA at senior high school. The learning given to the research subjects is a guided inquiry flipped classroom model.

The data collection technique in this study was carried out by providing a concept acquisition test in the form of essays totaling three items. The tests include indicators C3 to C5, which include hydrostatic pressure material, Pascal's law, and Archimedes' law. Each indicator of concept acquisition is represented by 1 question point. Instruments to measure students' concept acquisition in this study were given during pretest and posttest. The 3 points of research instruments used have been guided by expert lecturers, namely two supervisors, and have been valid after an empirical test, namely r calculate > 0.1857 (r table). Before learning with a guided inquiry flipped classroom, students are given a pretest to determine their initial knowledge. Furthermore, the teacher provided learning using the guided inquiry flipped classroom model in as many as five meetings with 10 lesson hours. After finishing the learning, researchers give posttests to students. Quantitative data analysis conducted in this study is in the form of increasing students' concept acquisition obtained from the results of paired T-tests and effect size tests to determine how much guided inquiry flipped classroom affects concept acquisition variables.

RESULT AND DISCUSSION

The results of Kolmogorov Smirnov's normality test, paired t-test, and effect size measurement can be seen in Table 1.

Table 1 Normality test, t-test, and effect size

Analysis	Result	Explanation
Normality	Pretest 0.061>0.05 Posttest 0.078>0.05	Normal
Paired t-test	0.000<0.05	Significant difference
Effect size	2.82	Strong effect

Table 1 shows that the pretest and post-test data of concept acquisition are normally distributed; the paired sample t-test analysis also shows significant differences in students' concept acquisition before and after learning with guided inquiry flipped classrooms. The results of measuring the effect size of concept acquisition data are 2.82, which is classified as very high; this reveals that guided inquiry flipped classroom affects concept acquisition. The percentage of student answers during the pretest and posttest, along with the category of student concept acquisition, are contained in Table 2.

Table 2 Student concept acquisition data

Material	Level	Percentage	
		Pretest	Posttest
Hydrostatic Pressure	3	3%	84%
	2	6%	6%
	1	6%	3%
	0	84%	6%

Material	Level	Percentage	
		Pretest	**Posttest**
Pascal's Law	3	3%	32%
	2	0%	16%
	1	29%	29%
	0	68%	23%
Archimedes' law	3	42%	65%
	2	13%	16%
	1	0%	13%
	0	42%	3%

Table 2 is a grouping of the level of concept acquisition of students who adopt categories from (Abraham et al., 1994), namely level 3 = acquiring the concept, 2 = acquiring partially, 1 = misconception, 0 = not acquiring the concept. The answer to the *hydrostatic pressure pretest* is that most students do not understand the concept. This is because students' answers have nothing to do with the questions. This is in line with research conducted by (Besson, 2004), which revealed that students have not been able to and have difficulty applying hydrostatic pressure in certain cases. The posttest answer to hydrostatic pressure for most students after applying the guided inquiry flipped classroom model is correct and classified as an acquisition of the concept. Students can already answer that what causes an increase in Δh_1 higher than Δh_2 is the density of water greater than gasoline, whereas hydrostatic pressure is caused by density and depth (Serway & Jewett, 2004; Serway & John W. Jewett, 2010).

Pascal's Law pretest answers most students are classified as not acquiring the concept. This is because the answer is not clear, has nothing to do with the concept, and does not match what is asked. This is in line with the research of (Hanni et al., 2018), which revealed that students have not been able to develop ideas to solve problems related to Pascal's Law. Students also have difficulty acquiring the pressure topic (Goszewski et al., 2013). The posttest answer to Pascal's Law for most students after applying the guided inquiry flipped classroom model is correct and classified as acquiring the concept. Students can already answer that points 1, 2, 3, and 4 in a closed space have the same pressure magnitude according to the sound of Pascal's Law (Serway & Jewett, 2004; Serway & John W. Jewett, 2010).

Most students' Archimedes Law pretest answers are incorrect and classified as not acquiring the concept. This is because the students' answers show that students have not been able to relate the lifting force to the weight of the fluid being moved. This is in line with research (Tseng et al., 2013; D. J. Wagner et al., 2009; Yin et al., 2008), which revealed students' lack of knowledge related to Archimedes' Law, thus causing students to misconceptions. Students also cannot explain what forces work when objects are fully immersed in a fluid, which aligns with research (Alfad, 2020; Diyana et al., 2020). The posttest answer to Archimedes' Law for most students after applying the guided inquiry flipped classroom model is correct and classified as acquisition of the concept. Students can already answer that objects in water are lighter because of the same lifting force as the fluid displaced (Serway & Jewett, 2004; Serway & John W. Jewett, 2010).

The increase in students' concept acquisition is due to the guided inquiry flipped classroom model that has been applied. This GIFC model guides students to learn independently and actively in the classroom (Limueco & Prudente, 2018; Maknun, 2020; Şenyiğit et al., 2019). In addition, in the learning process that uses analytical methods through investigations such as practicum, students can solve problems based on the facts they find. This helps students improve their concept acquisition on static fluid materials (Risman & Santoso, 2019). This learning also presents surrounding phenomena in the learning process so that students are encouraged to construct their knowledge through interactions between the experiences they have had with surrounding phenomena; this can correct student misconceptions (Rusche & Jason, 2011). The combination of the guided inquiry model with the flipped classroom approach is known to be effective because, at the flipped classroom stage, students are asked to watch learning videos, namely videos of static fluid-related phenomena at home. After that, students are asked to make hypotheses and problem formulations based on the videos they watch. Learning continues in the classroom with the inquiry stage, namely designing experiments, conducting experiments, and making conclusions. The GIFC learning step makes students actively involved in the learning process so that students' knowledge and acquisition are easily stimulated.

Based on the explanation above, it can be concluded that students' concept acquisition was low before implementing the flipped classroom guided inquiry model. The use of monotonous learning models can cause low concept acquisition during the pretest, and the way teachers teach is still with the old paradigm (Tompo et al., 2016). This makes students bored and lack active learning experiences. However, after the implementation of GIFC, students' concept acquisition increased. This follows the results of the effect size test of 2.82, which shows that the guided inquiry flipped classroom affects students' concept acquisition. In line with research conducted by previous researchers, the guided inquiry model can affect students' concept acquisition because, in the process, it involves students learning directly (Maknun, 2020; Yulianci et al., 2018). The flipped classroom approach also helps students develop their concept acquisition (Limueco & Prudente, 2018; Ramadoni & Mustofa, 2022).

CONCLUSION

Based on the results and discussions presented, it is known that students' mastery of concepts increases after applying the GIFC model. Therefore, it can be concluded that a guided inquiry flipped classroom is effectively used to improve students' conception of static fluid material. This learning model can also be applied to physics classes with different materials. The implication of this study is an increase in mastery of concepts in static fluid material after the provision of the flipped classroom guided inquiry model. In addition, it was found that the guided inquiry flipped classroom model affects students' mastery of concepts, as evidenced by the effect size test.

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